MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

ETN4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(All sections/Groups)

5 MARCH 2019
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) Using a suitable diagram, describe **two** differences between step-index and graded-index fiber.

[4 marks]

(b) A step-index optical fiber has numerical aperture of 0.3 and relative refractive index difference of 1.2%. The core diameter is 54 μm. Calculate:

(i) The core refractive index. [2 marks]

(ii) The cladding refractive index. [2 marks]

(iii) The acceptance angle in air. [2 marks]

(iv) The number of modes supported by the fiber at wavelength of 1.3μm. [4 marks]

(v) The cut-off wavelength for the fiber to operate as single mode fiber. [2 marks]

(c) State **two** common sources of **extrinsic absorption** in silica optical fiber. State **one** of the techniques used by the manufacturer to reduce the absorption. [3 marks]

(d) Briefly describe the following linear scattering problems.

(i) Rayleigh scattering [2 marks]
(ii) Mie Scattering [2 marks]

(e) Explain the intermodal dispersion problem in multimode optical fiber. [2 marks]

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Question 2 (25 marks)

(a) Give **two** differences between laser diodes and light emitting diode (LED). [4 marks]

(b) Population inversion and optical feedback are the requirements to achieve lasing condition. With the aid of a diagram, describe the basic semiconductor laser structure that provides the optical feedback and population inversion. [4 marks]

(c) Non-radiative electron hole recombination in LED affects its internal quantum efficiency. State **two** mechanisms that contribute to non-radiative recombination. [2 marks]

(d) Describe the process that provides internal gain in Avalanche Photodiodes (APD). [3 marks]

(e) A photodiode has a quantum efficiency of 68% at a wavelength of 850 nm. Calculate:

(i) The responsivity of the photodiode. [3 marks]

(ii) The photocurrent when the detector is illuminated with an optical power of 10 μW. [2 marks]

(iii) The rms quantum noise current with a post detection bandwidth of 25 MHz. [3 marks]

(iv) The signal-to-noise ratio (SNR) in dB, when the mean photocurrent is the signal. [4 marks]

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Question 3 (25 marks)

(a) Describe **two** advantages of an optical amplifier over optoelectronic regenerative repeaters. [4 marks]

(b) Using a suitable energy level diagram, describe the amplification process in Erbium-doped fiber amplifier (EDFA). [3 marks]

(c) State **two** advantages of erbium-doped fiber amplifiers over semiconductor laser amplifiers. [4 marks]

(d) An EDFA produces an output power of 30 dBm for an input level of 4 dBm at 1500 nm. Calculate:

(i) The amplifier gain. [3 marks]
(ii) The minimum pump power required when it is pumped at 980 nm. [2 marks]

(e) State **two** advantages of return-to-zero (RZ) over nonreturn-to-zero (NRZ) modulation schemes. In what type of communication system RZ is preferred than NRZ? [5 marks]

(f) Draw the frequency shift keying (FSK) and phase shift keying (PSK) signals for bit sequence of '10110'. [4 marks]

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Question 4 (25 marks)

As an engineer, you are assigned to design an optical fiber communication system to connect a few cities. The length of the link is 5300 km. The system should operate at a bit rate of 1 Gb/s with system margin of 7dB.

(a) Choose a suitable operating wavelength for your system (850 nm, 1310 nm or 1550 nm). State **two** justifications for your choice. [4 marks]

(b) Propose a suitable fiber type for your design. Justify your answer. [3 marks]

(c) Suggest a suitable optical source. Justify your answer. [3 marks]

(d) Suggest a suitable optical amplifier. Justify your answer. [3 marks]

(e) The receiver sensitivity of a few types of photodiodes is given in **Figure Q4(e)**. Based on the graph, select the best photodiode for your system. Justify your answer. [3 marks]

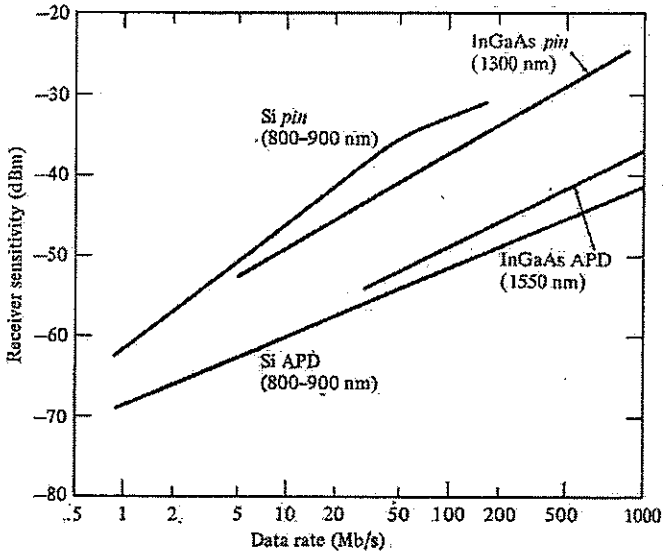

Figure Q4(e)

(f) If the maximum output power of the selected optical source is 0 dBm, determine the total allowable attenuation of the link (in dB). [2 marks]

(g) If NRZ signaling is used, calculate is the allowed rise time budget. [2 marks]

(h) If the selected receiver has 2.5 GHz bandwidth, find the receiver rise time. [2 marks]

(i) If the transmitter rise time is 25 ps, and the material dispersion rise time is 12 ps, calculate the total system rise time. Is the system rise time within the required limit? [3 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

End of Paper